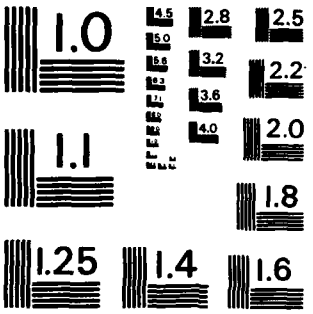
AD-A162 423 COMPOSITE STRENGTHENING(U) MARYLAND UNIV COLLEGE PARK ENGINEERING MATERIALS GROUP R J ARSENAULT 1985 N00014-85-K-0007 1/1

UNCLASSIFIED F/G 11/4 NL



NRL 031-875

12

ANNUAL REPORT

1985

COMPOSITE STRENGTHENING

OFFICE OF NAVAL RESEARCH

CONTRACT NO. N00014-85-K-0007

BY

R.J. ARSENAULT
PROFESSOR AND DIRECTOR
ENGINEERING MATERIALS GROUP
UNIVERSITY OF MARYLAND
COLLEGE PARK, MD 20742

SUMMARY

It has been demonstrated that a strong interfacial bond is required to produce the observed strengthening in discontinuous SiC/Al composites. Dislocation generation (which is the strengthening mechanism) is dependent upon a good bond existing between the SiC and the Al matrix.

Although it has been shown that the stresses developed in the matrix as a result of the differences in the coefficients of thermal expansion between SiC and Al are greatly reduced by the motion and generation of dislocations, an elastic residual stress can still remain.

An investigation was undertaken and it was determined that in the discontinuous SiC/Al composites a tensile-elastic-residual stress remains in the matrix. This determination is based on results from a theoretical model, tensile and compression testing and X-ray measurements. The results from all the tests and the model are in agreement. The magnitude of the residual stress is small, e.g., with 20 V% whisker in an annealed 6061 Al alloy matrix, the residual stress is 70 MPa. If the matrix is annealed 1100 Al, then residual stress is still smaller; 43 MPa.

The tensile residual stress produces a Bauschinger Effect (BE) which is highly dependent upon the initial direction of loading. If the initial direction of loading is in tension, the BE is small, if the initial direction of loading is in compression, the BE is very large.

It has been observed that as the strength of the matrix increases, e.g., due to alloying or age hardening, the percentage increase in yield

or ultimate tensile strength decreases for a given volume per cent SiC/Al composite. If the matrix is 1100 Al and 20 V% SiC whisker is added, then there is a 500% increase in strength, whereas, if the matrix is annealed 6061 Al alloy, there is a ~ 300% increase in strength. For annealed 7091 matrix the increase is ~ 200%. If the absolute magnitude is considered, the increase is greatest for 1100 Al matrix and decreases with increasing alloy content. The basic reason for this difference in strengthening is due to the change in the magnitude of the dislocation density and of the tensile residual stress. In the case of the 1100 matrix, there is maximum dislocation generation due to differences in coefficients of thermal expansion and a minimum tensile residual stress, because the yield stress of annealed 1100 matrix is less than the yield stress of the annealed 6061 and 7091 matrix.

Publications

1. INTERFACES IN METAL MATRIX COMPOSITES
   R.J. Arsenault and C.S. Pande
   Scripta Met., 18, 1984, 1131.

2. DEFORMATION IN SiC/Al COMPOSITES DUE TO THERMAL STRESS
   Y. Flom and R.J. Arsenault
   Mat. Sci. and Eng., 75 (1985) 151.

3. THE EFFECTS OF DIFFERENCES IN THERMAL COEFFICIENTS OF EXPANSION IN SiC WHISKER 6061 Al COMPOSITES
   Proceedings of the Fifth Internal Conference on Composite Materials, ed. by W.C. Harrigan, Jr., et al., 1985, p. 21.

4. INTERFACIAL BOND STRENGTH IN A 6061 Al/SiC COMPOSITE
   Y. Flom and R.J. Arsenault
   Accepted for publication in Mat. Sci. Eng.

5. AN IN SITU HOT STAGE TEM INVESTIGATION OF SiC-Al COMPOSITES
   M. Vogelsang, R.J. Arsenault and R.M. Fisher
   Accepted for publication in Met. Trans.

6. CRYSTAL STRUCTURE OF SiC WHISKERS
   R.J. Arsenault and J. Ahearn
   Submitted for publication.

7. RESIDUAL STRESSES IN FIBER METAL MATRIX COMPOSITES
   R.J. Arsenault and M. Taya
   Submitted for publication.

Papers in Preparation:

1. STRENGTH DIFFERENTIAL AND BAUSCHINGER EFFECT IN SiC/Al COMPOSITES
   R.J. Arsenault and B. Wu

2. DISLOCATION GENERATION DUE TO DIFFERENCES IN COEFFICIENTS OF THERMAL EXPANSION
   R.J. Arsenault and N. Shi

3. ROLE OF INTERFACES IN METAL-MATRIX COMPOSITES
   R.J. Arsenault and Y. Flom

Presentations:

1. Seventh Annual Meeting of Metal Matrix Composites 1985
   Strengthening Mechanisms

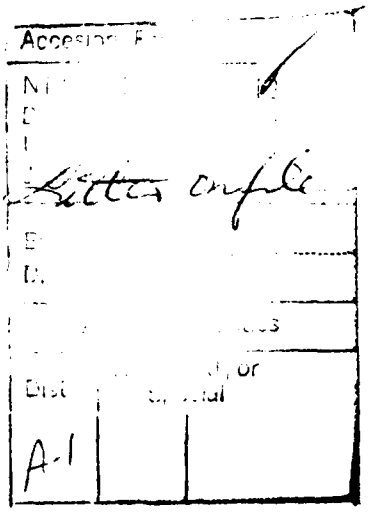
2. Fifth International Conference on Composite Materials 1985
   Thermal Residual Stresses in Short Fiber Composites.

3. Fall Meeting of AIME 1984
   Anomalous Diffusion at Interfaces in Metal Matrix Composites
   R.J. Arsenault and C.S. Pande

4. Fall Meeting of AIME 1984
   Fracture of SiC/Al Composites

5. Annual Meeting of AIME 1985
   Deformation in SiC/Al Composites Due to Thermal Stresses
   Y. Flom and R.J. Arsenault

6. Annual Meeting of AIME 1985
   Dislocation Distributions in Deformed SiC/Al Composites
   M. Lammers and R.J. Arsenault



END

FILMED

2-86

DTIC

END

FILMED

2-86

DTIC